

## CLAIMS

What is claimed is:

- 1 1. An apparatus comprising:
  - 2 a single network element including,
    - 3 a full TDM cross-connect coupled to every line card slot in said single
    - 4 network element with the same amount of bandwidth connection,
    - 5 wherein said full TDM cross-connect is programmable on an
    - 6 STS-1 basis, and
    - 7 a multiple ring unit to simultaneously support multiple TDM rings.
- 1 2. The apparatus of claim 1, wherein a line card with multiple ports can be  
2 installed in any one of said line card slots.
- 1 3. The apparatus of claim 1, wherein the amount of bandwidth connection is OC-  
2 48.
- 1 4. The apparatus of claim 1, wherein said line card slots number greater than 6.
- 1 5. The apparatus of claim 1, wherein said multiple ring unit includes:
  - 2 a protection group manager structure of which an instance is formed for each
  - 3 ring provisioned in said single network element, said protection group
  - 4 manager structure including,
    - 5 a ring ID to distinguish between the different rings simultaneously
    - 6 provisioned in said single network element, and
    - 7 a ring map.
- 1 6. The apparatus of claim 5, wherein said protection group manager structure  
2 further includes:
  - 3 an east and west protection unit to identify ones of said line card slots, as well
  - 4 as ports on line cards inserted in those line card slots.
- 1 7. The apparatus of claim 1, wherein said multiple ring unit includes:
  - 2 a line card manager structure of which an instance is created for each line card
  - 3 inserted in said line card slots;

4 a port manager structure of which an instance is created for each port of each  
5 line card inserted in said line card slots;  
6 a multi-ring manager structure to store identification information regarding each  
7 ring provisioned in said single network element;  
8 a protection group manager structure of which an instance is created for each  
9 ring provisioned in said single network element; and  
10 a network management system interface to be coupled to instances of said line  
11 card manager, said port manager, said multi-ring manager, and said  
12 protection group manager structures.

1 8. The apparatus of claim 7, wherein said protection group manager structure  
2 includes:

3 a ring ID to distinguish between the different rings simultaneously provisioned  
4 in said single network element, and  
5 a ring map.

1 9. The apparatus of claim 1, wherein the single network element is to transmit  
2 Operations, Administration, Maintenance and Provisioning (OAM&P) information  
3 within a first set of Data Communication Channel (DCC) bytes of a Synchronous  
4 Optical Network (SONET) signal to a first network element that is to connect to the  
5 single network element and to transmit the OAM&P information within a second set of  
6 DCC bytes of the SONET signal to a second network element that is to connect to the  
7 single network element, wherein a size of the first set of DCC bytes is different from a  
8 size of the second set of DCC bytes.

1 10. The apparatus of claim 9, wherein the first network element is to be included in  
2 a first TDM ring of the multiple TDM rings and wherein the second network element is  
3 to be included in a second TDM ring of the multiple TDM rings.

1 11. The apparatus of claim 1, wherein the single network element is to  
2 communicate to a different network element through a Synchronous Optical Network  
3 (SONET) signal such that the single network element is to communicate Operations,  
4 Administration, Maintenance and Provisioning (OAM&P) information to the different  
5 network element within Data Communication Channel bytes associated with any of the  
6 Synchronous Transport Signal (STS) frames within the SONET signal.

1 12. The apparatus of claim 11, wherein the SONET signal includes an Optical  
2 Carrier (OC)-48 signal.

1 13. An apparatus comprising:  
2 a single multiplexing network element including,  
3 a plurality of slots to be coupled to optical fiber of multiple TDM rings  
4 through line cards installed in said slots,  
5 a multiple ring unit to simultaneously support multiple TDM rings, and  
6 a full TDM cross-connect coupled to each of said slots with the same  
7 amount of high-speed bandwidth, wherein said full cross-connect  
8 is programmable to switch time slots between the different TDM  
9 rings.

1 14. The apparatus of claim 13, wherein a line card with multiple ports can be  
2 installed in any one of said plurality of slots.

1 15. The apparatus of claim 13, wherein the amount of high-speed bandwidth is OC-  
2 48.

1 16. The apparatus of claim 13, wherein said plurality of slots number greater than 6.

1 17. The apparatus of claim 13, wherein said multiple ring unit includes:  
2 a protection group manager structure of which an instance is formed for each  
3 ring provisioned in said single network element, said protection group  
4 manager class including,  
5 a ring ID to distinguish between the different rings simultaneously  
6 provisioned in said single network element, and  
7 a ring map.

1 18. The apparatus of claim 17, wherein said protection group manager structure  
2 further includes:  
3 an east and west protection unit to identify ones of said plurality of slots  
4 coupled to a given TDM ring, as well as ports on line cards inserted in  
5 those slots coupled to the given TDM ring.

1 19. The apparatus of claim 13, wherein said multiple ring unit includes:

2 a line card manager structure of which an instance is created for each line card  
3 inserted in said plurality of slots;  
4 a port manager structure of which an instance is created for each port of each  
5 line card inserted in said plurality of slots;  
6 a multi-ring manager structure to store identification information regarding each  
7 ring provisioned in said single network element;  
8 a protection group manager structure of which an instance is created for each  
9 ring provisioned in said single network element; and  
10 a network management system interface to be coupled to instances of said line  
11 card manager, said port manager, said multi-ring manager, and said  
12 protection group manager structures.

1 20. The apparatus of claim 19, wherein said protection group manager structure  
2 includes:  
3 a ring ID to distinguish between the different rings simultaneously provisioned  
4 in said single network element, and  
5 a ring map.

1 21. An apparatus comprising:  
2 a network element in a hubbed network office, said network element including,  
3 a plurality of line cards, wherein optical fiber from two different rings is  
4 directly coupled to said network element through one or more of  
5 said plurality of line cards;  
6 a multiple ring unit to simultaneously support the two different rings,  
7 and  
8 a full TDM cross-connect coupled to each of said line cards with the  
9 same amount of high-speed bandwidth, wherein said full cross-  
10 connect is programmable on an STS-1 basis and is programmed  
11 to switch certain time slots between the two different rings.

1 22. The apparatus of claim 21, wherein one of said rings is a TDM collector ring.  
1 23. The apparatus of claim 22, wherein another of said rings is a TDM collector  
2 ring.

1 24. The apparatus of claim 22, wherein another of said rings is a WDM or DWDM  
2 ring.

1 25. The apparatus of claim 21, wherein said two ring are a metro collector ring and  
2 a metro core ring.

1 26. The apparatus of claim 21, wherein one of said rings includes other network  
2 elements to which are coupled customer premise equipment.

1 27. The apparatus of claim 26, wherein said other network elements are coupled to  
2 said customer premise equipment by TDM access rings.

1 28. The apparatus of claim 21, wherein at least one of said plurality of line cards  
2 includes multiple ports.

1 29. The apparatus of claim 21, wherein the amount of high-speed bandwidth is OC-  
2 48.

1 30. The apparatus of claim 21, wherein said plurality of line cards number greater  
2 than 6.

1 31. The apparatus of claim 21, wherein said multiple ring unit includes:  
2 a protection group manager for each of said rings, each of said protection group  
3 managers including,  
4 a ring ID to distinguish between the two different rings, and  
5 a ring map.

1 32. The apparatus of claim 31, wherein each of said protection group managers  
2 further includes:  
3 an east and west protection unit to identify those of said plurality of line cards  
4 coupled to that protection group manager's one of the two different  
5 rings, as well as the ports on those line cards coupled to that ring.

1 33. The apparatus of claim 21, wherein said multiple ring unit includes:  
2 a line card manager for each of said plurality of line cards;  
3 a port manager for each port on said plurality of line cards;

4 a multi-ring manager to store identification information regarding the two  
5 different rings;  
6 a protection group manager for each of the two different rings; and  
7 a network management system interface coupled to each of said line card  
8 managers, said port managers, said multi-ring manager, and said  
9 protection group managers.

1 34. The apparatus of claim 33, wherein each of said protection group managers  
2 includes:

3 a ring ID to distinguish between the two different rings, and  
4 a ring map.

1 35. An apparatus comprising  
2 a single network element including,

3 a plurality of multi-purpose slots into which are inserted line cards,  
4 certain of said multi-purpose slots acting as aggregation  
5 interfaces are coupled to a ring, and certain of said multi-purpose  
6 slots acting as access interfaces are coupled to customer premise  
7 equipment with TDM access rings; and  
8 a full TDM cross-connect coupled to each of said plurality of multi-  
9 purpose slots with the same amount of bandwidth, wherein the  
10 sum of the bandwidth to the access interfaces is greater than the  
11 sum of the bandwidth to the aggregation interfaces, and wherein  
12 said full TDM cross-connect is programmed to groom traffic on  
13 said access interfaces to said aggregation interfaces.

1 36. The apparatus of claim 35, wherein one of said access interfaces includes a line  
2 card with a plurality of ports.

1 37. The apparatus of claim 35, wherein the bandwidth of said plurality of TDM  
2 access rings is greater than the bandwidth of said TDM collector ring.

1 38. The apparatus of claim 37, wherein the actual traffic on said plurality of TDM  
2 access rings is less than the bandwidth of said TDM collector ring.

1 39. The apparatus of claim 37, wherein said single network element further  
2 includes:

3 a protection group manager for each of said rings, each of said protection group  
4 managers including,  
5 a ring ID to distinguish between the different rings, and  
6 a ring map.

1 40. The apparatus of claim 39, wherein each of said protection group managers  
2 further includes:

3 an east and west protection unit to identify those of said line cards that are  
4 coupled to that protection group manager's ring, as well as the ports on  
5 those line cards coupled to that ring.

1 41. The apparatus of claim 37, wherein said single network element further  
2 includes:

3 a line card manager for each line card in said plurality of multi-purpose slots;  
4 a port manager for each port of said line cards;  
5 a multi-ring manager to store identification information regarding the two  
6 different rings;  
7 a protection group manager for each of the rings; and  
8 a network management system interface coupled to each of said line card  
9 managers, said port managers, said multi-ring manager, and said  
10 protection group managers.

1 42. The apparatus of claim 41, wherein each of said protection group managers  
2 includes:

3 a ring ID to distinguish between the rings, and  
4 a ring map.

1 43. The apparatus of claim 35, said network trunk is a WDM or DWDM ring.

1 44. The apparatus of claim 35, said network trunk is a TDM collector ring.

1 45. The apparatus of claim 35, wherein the same amount of bandwidth is OC-48.

1 46. The apparatus of claim 35, wherein said plurality of multi-purpose slots number  
2 greater than 6.

1 47. An apparatus comprising  
2 a single network element including,

3                   a set or one or more line cards coupled to one or more a network trunks,  
4                   a plurality of line cards coupled to a plurality of sets of one or more  
5                   pieces of customer premises equipment,  
6                   a full cross connect coupled to each of said line cards , wherein the sum  
7                   of the bandwidth between said full cross connect and said  
8                   plurality of line cards is greater than the sum of the bandwidth  
9                   between said full cross connect and the set of line cards, wherein  
10                  the bandwidth from said full cross-connect to at least certain of  
11                  said plurality of line cards is only partially used, and wherein  
12                  said full cross-connect multiplexes the used bandwidth of said  
13                  plurality of line cards to said set of line cards.

1   48.   The apparatus of claim 47, wherein one of said plurality of line cards has a  
2   plurality of ports.

1   49.   The apparatus of claim 48, wherein one of said plurality of sets of one or more  
2   pieces of customer premises equipment is coupled to said single network element using  
3   a TDM access ring.

1   50.   The apparatus of claim 48, wherein said plurality of line cards are coupled to  
2   said customer premise equipment with TDM access rings, wherein said network trunk  
3   is a TDM collector ring, and wherein the sum of the bandwidth of said plurality of  
4   TDM access rings is greater than the bandwidth of said TDM collector ring.

1   51.   The apparatus of claim 50, wherein said single network element further  
2   includes:

3                   a protection group manager for each of said rings, each of said protection group  
4                   managers including,  
5                   a ring ID to distinguish between the different rings, and  
6                   a ring map.

1   52.   The apparatus of claim 51, wherein each of said protection group managers  
2   further includes:

3                   an east and west protection unit to identify those of said line cards that are  
4                   coupled to that protection group manager's ring, as well as the ports on  
5                   those line cards coupled to that ring.

1 53. The apparatus of claim 50, wherein said single network element further  
2 includes:  
3 a line card manager for each of said line cards;  
4 a port manager for each port on said line cards;  
5 a multi-ring manager to store identification information regarding the different  
6 rings;  
7 a protection group manager for each of the rings; and  
8 a network management system interface coupled to each of said line card  
9 managers, said port managers, said multi-ring manager, and said  
10 protection group managers.

1 54. The apparatus of claim 53, wherein each of said protection group managers  
2 includes:

3 a ring ID to distinguish between the rings, and  
4 a ring map.

1 55. The apparatus of claim 48, said network trunk is a WDM or DWDM ring.

1 56. The apparatus of claim 55, wherein said single network element further  
2 includes:

3 a multiple ring unit that allows for multiple TDM rings to be coupled to said  
4 single network element simultaneous.

1 57. The apparatus of claim 56, wherein said plurality of line cards are coupled to  
2 said customer premise equipment through multiple TDM access rings.

1 58. The apparatus of claim 48, wherein the same bandwidth is OC-48.

1 59. The apparatus of claim 48, wherein said full cross-connect is coupled to each of  
2 said line cards with the same amount of high-speed bandwidth.

1 60. An apparatus comprising:  
2 a first and second network element each including,  
3 a full TDM cross-connect coupled to every line card slot in said single  
4 network element with the same amount of bandwidth connection,  
5 wherein said full TDM cross-connect is programmable on an  
6 STS-1 basis,

7 a multiple ring unit simultaneously supporting multiple TDM rings, and  
8 a plurality of TDM access rings coupled to line cards inserted in said line card  
9 slots of said first network element to connect different pieces of  
10 customer premise equipment;  
11 said first and second network elements coupled to a first TDM collector ring  
12 through line cards inserted in said line card slots;  
13 a second ring coupled to line cards inserted in said line card slots of said second  
14 network element.

1 61. The apparatus of claim 60, wherein said second ring is another TDM collector  
2 ring.

1 62. The apparatus of claim 61, wherein said second ring is a WDM or DWDM ring.

1 63. The apparatus of claim 62, wherein the sum of the bandwidth of the TDM  
2 access rings is greater than the bandwidth of the first TDM collector ring, and wherein  
3 said full TDM cross-connect in said first network element is programmed to groom  
4 traffic on said plurality of TDM access rings to said first TDM collector ring.

1 64. The apparatus of claim 60, wherein each of said first and second network  
2 elements further includes:

3 a protection group manager for each of ring provisioned in that network  
4 element, each of said protection group managers including,  
5 a ring ID to distinguish between the different rings provision in that  
6 network element, and  
7 a ring map.

1 65. The apparatus of claim 64, wherein each of said protection group managers  
2 further includes:

3 an east and west protection unit to identify those of said line cards in that  
4 network element that are coupled to that protection group manager's  
5 ring, as well as the ports on those line cards coupled to that ring.

1 66. The apparatus of claim 63, wherein each of said first and second network  
2 elements further includes:

- 3 a line card manager for each of said line cards in that network element;
- 4 a port manager for each port on said line cards in that network element;

5 a multi-ring manager to store identification information regarding the different  
6 rings provisioned in that network element;  
7 a protection group manager for each of the rings provisioned in that network  
8 element; and  
9 a network management system interface coupled to each of said line card  
10 managers, said port managers, said multi-ring manager, and said  
11 protection group managers.

1 67. The apparatus of claim 66, wherein each of said protection group managers  
2 includes:

3 a ring ID to distinguish between the rings provisioned in that network element,  
4 and  
5 a ring map.

1 68. A method comprising:  
2 transmitting a signal to a receiving network element;  
3 triggering a timeout mechanism;  
4 transmitting management information within a first set of Data Communication  
5 Channel (DCC) bytes of a Synchronous Optical Network (SONET) signal upon  
6 receiving an acknowledgement signal from the receiving network element prior to an  
7 expiration of the timeout mechanism; and  
8 transmitting the management information within a second set of DCC bytes of  
9 the SONET signal upon not receiving the acknowledgement signal from the receiving  
10 network element prior to the expiration of the timeout mechanism.

1 69. The method of claim 68, wherein the first set of DCC bytes is larger than the  
2 second set of DCC bytes.

1 70. The method of claim 68, wherein the management information includes  
2 Operations, Administration, Maintenance and Provisioning information.

1 71. The method of claim 68, wherein the management information includes  
2 Operations, Administration, Maintenance and Provisioning information from at least  
3 two or more rings of network elements.

1 72. A method comprising:  
2 transmitting management information to a receiving network element within a  
3 first set of Data Communication Channel (DCC) bytes within a Synchronous Optical  
4 Network (SONET) upon determining that the receiving network element can process  
5 the management information within the first set of DCC bytes; and  
6 transmitting the management information to the receiving network element  
7 within a second set of DCC bytes within the SONET signal upon determining that the  
8 receiving network element can process the management information within the second  
9 set of DCC bytes.

1 73. The method of claim 72, wherein the first set of DCC bytes is larger than the  
2 second set of DCC bytes.

1 74. The method of claim 72, wherein the management information includes  
2 Operations, Administration, Maintenance and Provisioning information.

1 75. The method of claim 72, wherein the management information includes  
2 Operations, Administration, Maintenance and Provisioning information from at least  
3 two or more rings of network elements.

1 76. A method for communication of management information within a Optical  
2 Carrier (OC)-48 Synchronous Optical Network (SONET) signal from a transmitting  
3 network element to a receiving network element, the method comprising:

4 transmitting, from the transmitting network element, a bit combination in Data  
5 Communication Channel (DCC) bytes within one of the last 47 Synchronous Transport  
6 Signal (STS) frames within the OC-48 SONET signal to the receiving network element;

7 starting a timer, by the transmitting network element, upon transmitting the bit  
8 combination in the DCC bytes to the receiving network element;

9 transmitting, from the transmitting network element, Operations,

10 Administration, Maintenance and Provisioning (OAM&P) information within at least  
11 one of the DCC bytes within one of the last 47 STS frames within the OC-48 SONET  
12 signal upon receiving an acknowledgement signal from the receiving network element  
13 prior to an expiration of the timer; and

14 transmitting, from the transmitting network element, OAM&P information  
15 within a first STS frame within the OC-48 SONET signal upon not receiving the  
16 acknowledgement signal from the receiving network element prior to the expiration of  
17 the timer.

1 77. The method of claim 76, wherein the OAM&P information includes  
2 information related to network elements that are located within at least two or more  
3 rings of network elements.

1 78. A machine-readable medium that provides instructions, which when executed  
2 by a machine, cause said machine to perform operations comprising:

3 transmitting a signal to a receiving network element;

4 triggering a timeout mechanism;

transmitting management information within a first set of Data Communication

## 6 Channel (DCC) bytes of a Synchronous Optical Network (SONET) signal upon

7 receiving an acknowledgement signal from the receiving network element prior to an  
8 expiration of the timeout mechanism; and

8 expiration of the timeout mechanism; and

9                   transmitting the management information within a second set of DCC bytes of  
10                  the SONET signal upon not receiving the acknowledgement signal from the receiving  
11                  network element prior to the expiration of the timeout mechanism.

1       79.       The machine-readable medium of claim 78, wherein the first set of DCC bytes  
2       is larger than the second set of DCC bytes.

1       80.       The machine-readable medium of claim 78, wherein the management  
2       information includes Operations, Administration, Maintenance and Provisioning  
3       information.

1       81.       The machine-readable medium of claim 78, wherein the management  
2       information includes Operations, Administration, Maintenance and Provisioning  
3       information from at least two or more rings of network elements.